

## Conservation and restoration of degraded ecosystems in arid and semi-arid areas of northwest China

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**Abstract:** In "West Development" of China, one of the most important activities is the Natural Forest Protection Program, designed to swiftly convert the focus of management and utilization of the natural forests from a timber orientation towards forest conservation, sustainable management and environmental protection. The project covered almost all the arid and semi-arid regions in Northwest region. Accompanying this great campaign this paper studied the conservation and restoration model of degraded ecosystems in arid and semi-arid lands in Northwest China. The past practices have resulted in considerably natural forest degradation and loss through land conversion (primarily for agriculture), over-harvesting, inadequate reforestation and lack of protection. The consequences have been the loss of soil and water resources, diminished timber production capacity on a sustainable basis, and environmental losses. This paper applied Aronson's restoration model and proposed the conservation, restoration, re-allocation and preservation program for the implementation of environmental improvement and natural forest conservation.

**Key words:** Degraded Ecosystems; Conservation; Restoration

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### Introduction

There is vast territory, with various ecosystems and great regional difference in China. With low and smooth terrain, humid climate, concurring rainy and hot season and relatively developed economy, the eastern part of China enjoys relatively favorable natural conditions. The western part of China suffers from rare precipitation, drought, high elevation, cool climate, poor transport facilities, less developed economy and harsh natural condition. In order to reach to a balanced development the Chinese government has launched the strategic decision of "Western Development" in the next decades. The objective is to exploit western resources, to improve the living condition of the local people, and to protect the western environment at the same time.

Environment and development are major issues of general concern in the international community. Environment conservation of realizing sustainable development has become an urgent. It has been internationally recognized that forest plays a crucial role in achieving balance between environment and development. As a major component of the terrestrial ecosystems, forest is the richest nature's reservoir of resources, biological gene, water, carbon and energy. Forest is a key element of indispensably natural re-

sources for human and socioeconomic development, and particularly for the developing countries that are striving to lift themselves out of poverty.

The forests on the middle and upper reaches of Yellow River and the upper reach of Yangtze River play an important role in reducing silt content and regulating volume of river flow. Yangtze and Yellow River are the two largest rivers and are also the most fragile environmental sites in China. So the forests in the middle and upper regions must be protected so as to meet the needs of environmental protection and natural resource sustainable management. Accompanying the national western development strategy the Chinese government launched the National Natural Forest Conservation Program (NFCP) to protect national natural forests, prevent soil and water erosion, and protect ecological environments of some large rivers. The program includes all the forest sectors of different ownerships: state-, collective-, and private-owned. Main activities cover all the northwest provinces (autonomous regions), including the arid and semi-arid ecosystems. The program will also result in about 1.2 million laid-off workers in forest areas redirecting to new posts and relating, to some different extent, near 5 million people in forest areas. Both the western development and the NFCP only outline the planning for most important aspects of the nation's territorial eco-environmental improvement, including protection of natural resources, soil and water conservation, desertification combating, grassland rejuvenation, ecological agriculture, etc. in the whole western parts of China.

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## Resources and environment of the northwest region

The land area of the northwest five provinces covers  $309 \times 10^4 \text{ km}^2$ , it accounts for about 1/3 of the national territory. By contrast there are only  $7\,952 \times 10^4$  residents, the population density reaches to  $0.038 \text{ km}^2$  per capita, that is one of the most riches regions not only in China but also in the whole world. Nevertheless, the vast land does not mean to extend living space for the local people. In fact the effective area for the northwest people is very limited because of the following reasons. The first is the wide area with non-matching resources. Most of the lands can't be utilized for the agriculture or forestry. The areas of sand and desert are accounted for 28% in the northwest region. The available lands are very limited, more than 96.3% of them are the dry land and 70%-90% of them are distributed in the mountain slopes. Soil resources are seriously damaged by intensive tillage of more than two thousand years. So that productivity decreases year by year. The second is the relative shortage of water resources. The northwest region is short in water resources, which are allocated unevenly over the region, and water quality is poor. Some parts are the water mineralized and salted. The third is the harsh climate condition. The region is characterized by a small amount of precipitation (less than 200-400 mm/a), large amount of evaporation (more than 300-400 mm/a), longer period of dry season (from September to February next year), shorter period of frost-free season (110-150d), and frequent blast wind over the year.

The forest coverage in the west region is only 1.85% and is almost about 1/8 of the country's average. Worse still, the forests are still being disrupted as the local people depend on, to a certain extent, the forest resources to live. A large and increasing population and the unsustainable overuse of forest resources are not only major economic impedimental factors but also, are a prominent environmental issue affecting soil conservation, water supplies and water quality. These directly influence the sustainability of food supplies and livelihood of communities. Conservation natural resources and environmental improvement are the most prominent in the arid and semi-arid northern provinces.

Northwest China is the typical arid and semi-arid region, most natural forests have been disturbed for more than two thousand years, so that they are also typical degraded ecosystems. These areas play a key role in national environment improvement. Their environment status could directly influence the quality of environment in the whole country and even in Asia. Wood logging was the main economic activity and

timber selling was the main commercial market. The residents in and near the forest areas depend on the forest resources for their life. The only raw material management has limited the economic development and caused poverty for the local people. Poverty has weakened the local people's ability to use natural resources wisely so that the factors above brought about the results of over-consumption of natural forest resources, serious loss of ecological functions of the forest and deterioration of ecological environment with frequent occurrences of natural disasters. The main problem that we are facing is how to protect or restore deteriorated natural forests and to improve the ecological environment as soon as possible.

## Restoration of the degraded ecosystems

Aronson *et al.* (1993a, b) proposed a general model to describe ecosystem degradation and to help to decide when restoration, rehabilitation, or re-allocation should be the preferred response. This model can be used for the degraded ecosystem restoration in the arid and semi-arid northwest region of China because it was derived and applicable in the African arid and semi-arid lands that shared almost the same climate and environmental condition with the northwest China. Aronson *et al.* (1993a) defined: "Restoration aims at the complete return of a site to a pre-existing state from a taxonomic point of view--the reestablishment of all indigenous species and the extirpation of all exotics; Rehabilitation concentrates on repairing damaged or blocked ecosystem function, with the primary goal of raising ecosystem productivity quickly yet sustainable; Re-allocation usually disregards the indigenous ecosystem while imposing new uses on the site". Fully considering the northwest reality we added two alternatives, conservation and preservation, and included rehabilitation and restoration in the same category.

## Conservation

Conservation is man's activities of managing natural ecosystems in order to protect them from further disturbances or further degradation. We not only conserve the natural forests *in situ* but also protect the rare and endangered species, the seeds and the organs of some important organisms *ex situ*. Although a great many of natural forests have been influenced by human beings, there are still large areas in the high mountains and steep slopes so that man can never reach. These belong to the primary forests and should be conserved. Another kind of conservation object is the forest or vegetation that have stopped at certain succession stage and have changed less in their composition and structure in the natural conditions, namely the climax vegetation and

dis-climax vegetation in the sense of Clements and Tensly (Kimmins 1987). We can use the methods of closing forests and establishing natural reserve and national parks to conserve the forests and other kinds of vegetation resources.

### Restoration

We put rehabilitation into this restoration category because the objective is to help the secondary and other degraded ecosystems to transmit to their primary vegetation type. The restoration includes also repairing the structure, function and dynamics of the damaged ecosystems. The restoration ecosystem can recover to their original vegetation or some stable status. There are large amount of secondary forests and degraded primary zonal vegetation that need to be restored. The northwest is an up-reach region of many large rivers, the degraded natural forests allocated over the high mountains, steep slopes, both sides of rivers, and sources of streams should be well restored.

### Re-allocation

Re-allocation has almost the same sense with Aronson's model. It is almost impossible to restore the seriously damaged ecosystems that one or more irreversible thresholds have been passed. Some of the new ecosystems have to be reestablished even they have not any relations in the viewpoint of community structure and succession series. By allocation we can develop artificial forests or some high productive woods that do not necessarily bear an intrinsic relationship with the pre-disturbance ecosystem's structure or functioning. Re-allocation responses to the circumstances that the original vegetation has completely damaged and it is almost impossible to restore without high input and intensive disturbance.

### Preservation

There is large amount of ecosystems completely destroyed and sometimes the original soil disappeared, too. We can neither restore nor reallocate in these sites, but only preserve them from further degradation because none of the original or high productive plants can establish easily or grow well in this habitat. The human activities of more than two thousand years in the northwest China, some parts have become naked rocks, moving dunes and marsh. We cannot improve the site condition overnight since both soil features and local environment must be changed progressively and successively. It has been known that planting trees will decrease the ground water in some arid regions, especially in the Gobi desert planting trees like setting up the pumps to draw water from the ground and finally cause the water depletion. And some nearby villages and resi-

dents can be influenced. Site condition determines whether and what we can plant. So preservation is the useful protective consideration.

### Application of the model

Based on the above discussion we selected Xiaolongshan Forestry Bureau of Gansu Province as pilot site since it is typical and important in the view-point of forest resources and environment improvement. It is situated at the upper reaches of both Yangtze and Yellow River: the water in the south Qinling Mountain runs down to the Yangtze river and the water in the north Qinling Mountain runs down to the Yellow River (Table 1).

**Table 1. Land statistics between different valleys**  $\text{hm}^2$

Valley	Total area	Forest area	Non-forest area	Forest coverage %
Yellow River	227 606	141196	86410	62.0
Yangtze River	601 093	475882	125211	79.2
Total	828 699	617 078	211 621	74.5

Xiaolongshan Forestry Bureau has the typical natural forests, which plays the key roles for the protection two largest rivers from sand, silver sediment and frequent flooding. More than 90% of the land situated at the slope degree of more than  $25^\circ$  and this environmental condition has retarded the economic development (Table 2). There are many different forests, varied types, natural reserves, dunes, and cultivated fields. The shortage in water resource is the most important environmental reason for the backwardness in the living condition of the local residents.

**Table 2. Forest and cultivated areas in different slope degree**  $\text{hm}^2$

Slope degree/( $^\circ$ )	Forest area	Percentage	Cultivated area	Percentage
<25	18 512	3.00	7 040	7.00
25 ~35	111 074	18.00	90 513	90.00
>35	487 492	79.00	3 017	3.00
Total	617 078	100.00	100 570	100.00

Forest management is relatively difficult because of the long history of human activities and disturbances in the region. The natural secondary forests dominated in the whole bureau and the potential forest resources cannot meet the wood needs of the local development forestry. Particularly there exist complex relations between the forestry bureau and the boundary agricultural areas. In order to implement the NFCP, the forestry bureau must solve not only the laid-off forestry worker problems but also the poverty and starvation problems of the boundary peasants

after the suddenly stop of the wood harvesting in the whole area.

With the implementation of the NFCP most of the residents in the forest region lose, to an extent, their living incomes. The local people even become poorer, and therefore nothing could be done before the starvation problems were solved. Xiaolongshan Forestry Bureau faces many challenges: *e.g.*, how to evaluate and classify the natural forests so as to conserve and restore the degraded natural forests; how to convert the cultivated land of more than 25° slope degree to the forests; how to help more than 8 000 laid-off workers and nearby relevant local people, to a certain degree, on the forestry bureau, to find new jobs after the wood production decreased by the NFCP; how to find and develop the new industries and new non-timber incomes so as to alleviate poverty for the local publics; etc..

The economic development is relatively backwards and the living condition of the local residents is quite poor, so timber cutting and wood industry are the main economical income. Poverty prevented them from sustainable use the forest resources that caused the rapid decrement of the forest resources. So there exit natural disasters, especially the soil and water erosion in the nearby and the down reach regions. Xiaolongshan Forestry Bureau has a large area of the transit zone of forest-cultivated land, complicated community problems and almost depleted mature natural forests (2%-3%).

Xiaolongshan Forestry Bureau is situated at the southeastern part of Gansu Province. The geographical location is 33°31'-34°41' in latitude and 104°23'-106°43' in longitude. It has the typical climatic characteristics of both the northern and the southern secondary forests. Qinling, one of the highest mountains and the protected sites of the middle-upper reach of Yellow River of China, is just situated at the region. The altitude ranges from 700 to 3 200 m, but most parts are within 1 500-2 000 m. The annual precipitation is about 400-600 mm and the annual air temperature is about 7-12 °C. The total frost-free season is 170-220d. The climate belongs to temperate arid and semi-arid forest grassland region that can allow many kinds of animals and plants to distribute here. Xiaolongshan Forestry Bureau is considered as the key natural forest conservation and restoration area for China's NFCP from the point of view of natural environmental conditions.

There are 3 natural reserves in the bureau; total area reaches to 14 800 hm<sup>2</sup>. Xiaolongshan Forestry Bureau has 828 699 hm<sup>2</sup> managed lands, accounting for 1.83% of the total area of the Gansu Province, of which area of 617 078 hm<sup>2</sup> is the forest lands and 211 621 hm<sup>2</sup> non-forest lands. They account for 74.5% and 25.5% of the total managing lands, re-

spectively (Table 1). Among the forestlands, the area and the stock volume of the young growth, middle-aged forests and old-growth of forests account for 18.8% and 7.0%, 65.9% and 70.5%, and 15.3% and 22.5%, respectively. The forest coverage is 52.5%.

The administrative area of Xiaolongshan Forestry Bureau is crossed over Tianshui, Longnan and Dingxi city including 8 counties, 89 towns and 1920 villages in the forest region. In Xiaolongshan Forestry Bureau there are 470 000 residents in which more than 6 000 workers are included. Agriculture plays an important role in the local economy. According to the statistics in 1994, the output values in agriculture, forestry, and pasture account for 71%, 5.9% and 23.1%, respectively. The mean incomes of the local peasants are 800 RMB per capita.

Based on the natural and socio-economical conditions above in the forestry bureau alternative means should be considered for the restoration of the degraded natural forests. It was proposed that all the protected areas and high mountain ridges should take the means of conservation. The degraded ecosystems including secondary forests, overused forestland and cultivated land with the slope more than 25° should take the means of restoration and rehabilitation. The artificial forests and cultivated lands with a slope less than 25° should take the means of reallocation. The seriously degraded ecosystems, particularly those the soil has been lost or completely changed over the longtime of exploitation. In short upper reach regions of both Yantze River and Yellow River are the critical sites for the conservation of soil and water conservation so that all the degraded ecosystems should be restored or rehabilitated by a proper way. Meanwhile the local people in the forest regions are the most important factor for the successful restoration. Forest protection shouldn't neglect the living condition improvement of the local people. Effective means of restoration includes the efforts to help the local people to avoid of poverty. Economic development may be encouraged in accordance with the restoration practice.

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